Digitalization and Financial Inclusion in Sub-Saharan African Countries

Fadeke Elegbe[1], Shehu Abdul Rahman[2] & Ilemona Adofu[3]
[1,2&3]Department of Economics, Federal University of Lafia, Nigeria
Corresponding Email: elegbefadekemi@gmail.com

Abstract

Financial inclusion (FI) has gained increased academic and policymaker attention in recent years, however, the effect of digitalization on financial inclusion has not sufficiently been undertaken. Hence, this study examined digitalization's effect on financial inclusion, using Sub-Saharan African countries data, covering the period 2005- 2021. To conduct this study, a panel dataset covering Sub-Saharan African countries was used. Principal Component Analysis (PCA) was used in computing the indicators of the financial index from its sub-indices of access, usage and quality indicators, while the System Generalised Methods of Moments (SysGMM) was used to confirm the effect of digitalization on financial inclusion in Sub-Saharan Africa. The results revealed that there was a long-run significant positive effect of digitalization on consumers' financial inclusion in SSA. The results also revealed that the coefficient of per capita GDP was significant and positive in the short run but becomes insignificant in the long run. Consequently, digitalization will have a positive effect on consumers' financial inclusion in SSA countries in the long run, provided good policy implementation are put in place which will culminate in the democratization of financial services, and increased social welfare and economic growth. Also, it will enable the government in reaching the poor people residing in remote areas, and digital literacy will be enhanced. Policy makers and digital financial service providers of the SSA countries can leverage the study's findings to improve the frontier of financial inclusion in their countries.
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1.   Introduction

Technologies are evolving so much that there are no areas that have not been affected and no walls that have not been occupied. Digitalization is transforming how individuals and banks conduct business. In a world where time is crucial, this has drastically altered the social, political, economic and work environment and has been integrated into virtually every facet of

education, commerce, health and governance in high-income countries in the wake of COVID-19 pandemic, the technology is playing a swift and important role expanding financial inclusion for the poor, i.e. the unbanked and underbanked. Digital financial systems are allowing the expansion of the formal financial economy.

For instance, studies indicate that more than 50 per cent of the poorer 40 per cent of the population in developing economies do not have formal accounts; and about 35 per cent of start-up companies are excluded by the formal financial institutions from obtaining credit (Ozili 2020). In 2010, the Consultative Group to Assist the Poor (CGAP/World Bank Group) survey, shows that the percentage of unbanked poor are much less in sub-Saharan Africa than global average with the high-income countries having higher rates (World Bank, 2 014).

The regions of sub-Saharan Africa and South Asia have the lowest share of households with access to a bank account, expressed as a percentage of a country's adult population. Rural communities where some of the world's active poor and those experiencing multidimensional poverty reside are also those that would underpin growth in most economies. Therefore, they stand to benefit the most from utilizing formal financial products. High levels of financial inclusion (access to formal financial products) are vital for achieving the UN Sustainable Development Goals (Maruf & Aryani, 2019). At the same time, large disparities exist between youth and men and female rural populations (who tend to be smallholder farmers) regarding access to formal financial products. Applying the lenses of geographic and gender segmentation indicates huge divides, over formal financial product access, between urban and rural, between men and women, and across developing regions (Ratna *et al.*, 2015; Lyons & Kass-Hanna, 2021; Neaime & Gaysset, 2018).

While we can see economic growth and many of the financial institutions seem to advance on paper, we must also take into consideration that there are still many people in Sub-Saharan Africa whom big banks and other formal financial services have not managed to reach in places like South Africa, Kenya, Mauritius, Tanzania, Ghana and Nigeria (Uzoma, Adegbite, Omakhanlen, Okoye, & Isibor 2020). One of the key factors into having and attaining an inclusive finance would be digitalization.

The new fad in the finance sector is digitalization. Confronted with technological innovations, they view digitalization as a new way to respond via the financial and digital technology revolution. Great consequences in form of economic, financial, social as well as political awaits those who cannot benefit from financial products or services today and in the future (Abor, Amidu, & Issahaku (2017). One of the key policy standards is the cashless

policy, leading to minimizing or eliminating cash for economic and financial transactions and the requirement for financial identity, bank verification number for all. Without the number, you cannot bank. Second is the e-dividend policy: dividends should be paid directly to your current account as owner of the shares rather than pay in cash. Yes, you are a share owner or a beneficiary of a trust (Gabor & Brooks (2016)

The pension policy regulates that pension proceeds is paid through a current account at a bank (micro-pension), the claim must be made through a designated account (micro-insurance), and so on. Policy makers and researchers now see digitalization as an enabler of financial inclusion for economic growth and poverty reduction. This is because many of the challenges are still there and undermine the usefulness of digital finance for households, firms, governments and economies as a whole (Myovellaa, Karacukaa, & Haucap, 2020). Addressing these issues might significantly increase the potential of digital finance. Digitalization improves the user experience of financial services users, of those who work in digital financial institutions, the states that allow such offerings, and for the entire economy, when financial inclusion helps poor people access finance, and financial institutions (both banks and Fintechs) cut the cost of intermediation (Francis, Stuart, & Wellalage (2017).

The UN Sustainable Development Goal of ending poverty by 2030 is not possible without achieving the target of having financially inclusive systems that are sustainable. Closing the gaps in the financial system, by scaling up digital financial systems, can improve everyday life of many millions. Therefore, the unbanked population or the underbanked population need to be on-board into the financial services sector. This can be done by using digital technology to lower the cost of service delivery, reach the unbanked at their doorstep, end to end digital service with minimum documentation compared with traditional banking accounts, and small loan products for the rural poor at zero or close to zero cost. So that they can secure their investment. Apart from that, advisory services can be offered related to investment in the future direction for customers fund so that they can use their fund in the right manner.

Therefore, this study focuses on the position of digitalization furthering the financial inclusion in SSA. The study would help the financial institutions in making sure that the standard of living of poor-families, the farmer, local people, the less privileged, unemployed, Small and Medium Enterprises (SMEs) women and youth who are unbanked and underbanked would have a good platform where they have access to finance digitally, and also create an awareness on the significance of digitalization in achieving financial inclusion.

2.   Literature Review
2.1   Conceptual Clarification
2.1.1   Concept of Financial Inclusion

Conceptually, it is imperative to articulate a definition of financial inclusion to sustain and develop an ideological construct and reveal the foundational components that influence its trajectory and implementation. There is not generally accepted and agreed definition of what financial inclusion is; one that takes account of all relevant considerations. Earlier work has shown that the as-yet elusive nature of financial inclusion differs from country to country and from one geography to another, and is a function of a country's economic, social and financial development and, indeed, the very visions that the underserved themselves have for its reach and relevance. Financial inclusion broadly captures how easily and at what cost people, families and enterprises can access financial services (Ozili, 2018).

Financial inclusion (FI) was made the global development agenda, most recently, when G20 leaders pledged to 'ensure sustainable financial inclusion for all' in 2010. Defined by the G20 as 'ensuring that all individuals and businesses have access to and use of suitable, affordable and sustainable financial services and products, provided by institutions they trust, to meet their diverse everyday needs efficiently', FI allows individuals and business to make their contribution to economic growth and participate in development opportunities (Ozili 2020).

Ma'ruf and Aryani (2019) have highlighted that financial inclusion corroborates the United Nation's SDGs by promoting economic progress and stability of the financial system. This process helps to reduce inequality and poverty rate in developing countries (Park & Mercado, 2015; Turegano & Herrero, 2018). However, there have been varied responses from different countries with respect to the responses to financial inclusion goals. It is important to note that however that digital financial institutions contribute immensely to financial inclusion by facilitating transactions remotely through mobile devices and thereby ensuring access to financial products by different economic agents (Lyons & Kass-Hanna, 2021; Neaime & Gaysset, 2018, Gomber, Koch, & Siering, 2017; Pearce, 2011).

As noted, the 'unbanked' and the 'underbanked' are often the objects of financial inclusion efforts that seek to provide these people with long-term credit and other services. The goal of getting the unbanked into the formal banking system is seen as essential to long-term economic health and development in many countries around the world. And many governments have made reaching that goal a top priority. While financial inclusion and access to finance are often seen as interchangeable concepts, they are not the

same. which defines financial inclusion as: 'the absence of barriers, whether physical or electronic, infrastructural or institutional, regulatory or cultural, that prevent consumers (households or businesses) from accessing and using quality financial products and services at affordable costs.' Consequently, indexes of access, quality and usage are applied to evaluate financial inclusion policies and programs. The reason for the above definition is that they focused on the three most critical dimensions of financial inclusion: not just access to finance but also the fact that individuals can be considered financially inclusive if usage of services by individuals, households and firms occurs at affordable costs and is mostly for those who have otherwise been financially excluded.

The definition of access used in the study draws on that proposed by Naumenkova, Mishencho, and Dorofeive (2019), who define financial inclusion as the presence of no barriers, cost or otherwise, that deny anyone, individually or otherwise, access to, and use of, formal financial services in a timely and complete manner. This is why quantitative and qualitative indicators of access, quality as well as usage are now used to measure programmes and policies rooted in financial inclusion. They did this for good reason – the three fundamental dimensions of financial inclusion are meaningfully captured in this definition (clearly, it was not 'access to finance' alone). For one, if individuals, households and firms can be said to be financially inclusive, then usage of finance in analogue and digital forms by individuals, households and firms at an affordable cost must also be included (cost lies at the centre of the definition). Two, if it is groups of individuals that become financially excluded, then the inclusion of a reference to usage of financial services in any notion of 'financial inclusion' is also appropriate.

2.1.2   Concept of Digitalization

In the absence of any given clear-cut definition of digitalization, we may say that it encompasses all financial services and products delivered remotely by financial service providers. Digitalization here becomes the process of digitalizing the financial sector of the economy termed digital finance. The above definition of digital finance given by (Manyika, Lund, Singer, White and Berry (2016) reads: Digital finance collectively refers to all of the financial services and products delivered remotely to customers in all locations by all financial service providers.

Thus, here digitalization means digitalizing the financial sector of the economy usually known as digital finance. Manyika, Lund, Singer, White, and Berry (2016) define the term digital finance as 'financial services delivered over digital infrastructure with limited use of cash and bank branches. Technological disruptions have transformed virtually every pocket of the

economy. This includes Cashless Policy that restricts economic and financial transactions to almost zero cash usage. There is also the requirement for possessing a bank verification number for all banking transactions; the e-dividend policy mandating that dividends be paid directly to shareholders' current account; pension policy that the proceeds of the pension accumulate through a dedicated current account (micro-pension); and insurance policy that pays the claims to the Insured through a dedicated account (micro-insurance). Above all, the COVID-19 pandemic has highlighted the need for a technology-based economy.

Digitalization of the financial system is relevant to financial inclusion because governments' attempts through microfinance and other government schemes failed to guarantee that cheap financial services could reach the poor, especially the subsistence farmers (Turegano & Herrero, 2018). The financial cost is cheaper for MFIs in Sub-Saharan Africa, but their operational costs are much higher because they don't have good physical and financial market infrastructure.

Although sub-Saharan Africa has higher interest rate for its financial market, lending money to individuals and businesses has produced some deficiency as Sub-Saharan also recorded loan loss rate which rose to 5 per cent in 2012–14, becoming the highest loan loss record in Africa (Demirguc, Klapper, & Singer 2017). Even though Micro Finance Institutions are contributing to financial inclusion; they also share the booms and bursts phenomena, which imply when any meaningful crisis takes place, confidence can be badly affected and current financial deepening will be impaired, with the poor also paying the higher cost (Uzoma *et al.* 2020).

But after several ripple effect of crisis surroundings, immediate action is needed to deal with threats. Most of the unbanked population are poor people from rural areas, and this is a market that needs simple and safer financial transactions, which formal financial institutions must address through the development of relevant products. In light of this, financial inclusion can be facilitated by accelerating the expansion of digitalization in rural areas.

Experts on financial inclusion believe that a number of variables, including technology, suitable rules, policy infrastructure and well-designed financial derivatives are required for initiatives to enhance the take-off of financial inclusion and have a significant influence on the communities. Thus, improving the electrical and communications infrastructures which represent the largest impediments to more rapid digitalization by government, private industries and NGOs, is the best way to speed up the spread of digital financial inclusion and thereby realise the full capability of improving financial inclusion (Demirguc *et al.,* 2017). Due to the economic lockdown, a new normal way of life will emerge, bringing with it new economic powers, new

technological breakthroughs, and new operating norms that will alter the global economy (Seshamani, 2018). Work-from-home and social isolation are increasingly popular, and financial institutions are not excluded from this trend.

2.2   Theoretical Literature
2.2.1   Technological Acceptance Theory (TAM)
Davis (1986) postulated the theory and has become possibly one of the most used theoretical models in the field of technology. With their exponential growth and increasing role in users' every day and professional life, the issue about approving or not approving technology is still to be settled. The TAM model has evolved into one of the main tools for predicting human interaction with potential technology adoption or rejection. Similarly, the model of technology acceptance focuses on the individual, and fragments human actions through the technological change in a unilateral process of social change (Legris, Ingham, & Collerette, 2003).

2.2.2   Diffusion of Innovation Theory (DIT)
The digitalization and financial inclusion are social because the research is related to its diffusion. To understand how innovation such as Digitalization or financial Inclusion is disseminated into society, diffusion of innovations theory (DIT) is adopted. The theory is developed by Rogers, Singhal, and (2014), which is about the process through which humans adopt new ideas. In this context, innovation is a solution to present human problems, while the adoption of innovation is the incorporation processes of an innovation into the behaviour of individuals, organizations, and society. To understand the innovation-adoption process, DIT is developed regarding how new ideas and products are disseminated into society through communication channels over time, and it is composed of five determinants: innovation, adopter, communication channel, time and the social system. DIT unlike TAM, which refers to individual adopting of innovations and how an individual and their organization and the adopter, in DIT one sees innovations' processes, DIT expounds five phases in the innovation-adoption process: knowledge, persuasion, decision, implementation and confirmation. As the diffusion is related to time; it can be at individual and at the organizational levels; also, social networks. In addition, the second determinant, adopter, is the technology users

The third determinant, communication channel, is the passage in the diffusion of innovations; the diffusion is made by five phases: knowledge, persuasion, decision, implementation, and confirmation. Second, from the theory, the author stirs the notion that just because a calculator, such as the one

innovated by Babbage, failed to spread, it would be erroneous to make a statement that nobody has adopted it. That would rather mean that an innovation failed to attain widespread adoption rather than a claim that an innovation has no adopter. Babbage's calculator was just a weak innovation because it competed with other strong inventions (Albastaki, 2022; Yoon & Lim, 2020).

2.3   Theoretical Framework

Digitalization promotes financial inclusion and serves as a great mechanism that will enhance the inclusion of the less privileged, poor and rural dwellers into the financial system through knowledge, persuasion, decision making and implementation. Thus, financial inclusion using digitalization channels, such as mobile internet and telephony networks and financial literacy can connect the unbanked or underbanked poor in remote locations to the conventional banking system, justifying the adoption of the diffusion of innovation theory. Acceptance of these products or services will encourage people to place their faith in the banking institution and accept more of its offers, resulting in increasing financial and economic growth. As a result, the impoverished will be able to save money for themselves and their families, and will be lifted out of dire poverty

2.4   Empirical Review

Several studies have empirically investigated the relationship between digital finance and financial inclusion. However, our review of the previous studies is outlined below which concentrates on the contribution of digital finance on financial inclusion mostly in underdeveloped countries.

In their study, Duvendack and Mader (2020) performed a systematic review of reviews and, they in turn uses ordinary least square as a technique. The thirty-two systematic reviews they engaged with showed that the outcome of financial accessibility efforts is very much more often positive than negative, it can enhance economic, social, gender and behavioural outcomes. They came to the conclusion that financial services had a minor and inconsistent influence on fundamental economic and social poverty indicators. Therefore, there is no indication of significant behaviour change. They also discovered that while the benefits on women's empowerment appear to be generally good, they are dependent on program aspects that are typically unrelated to financial services, as well as cultural and regional context. Savings possibilities have a tiny but persistent positive impact on poor people, and they pose fewer risks to consumers than credit. The variable quality of the primary empirical basis that constituted the foundation of their summaries raises doubts about the overall findings, which is one of the study's significant flaws.

Fernandes, Borges, and Caiado (2020) employed the Autoregressive Distributed Lag (ARDL) model from 2011 to 2019 to examine the degree to which digital financial services contribute to financial inclusion in the Mozambique context. Two approaches were considered when calculating the tenacity of digitalized financial activities to financial inclusiveness. The findings revealed that digital finance as an aggregate has a good impact on financial inclusivity in Mozambique, especially payment instruments such as ATM, CBR and POS (traditional) and e-money (novel). With the exclusion of domestic remittances and Direct Debit (CCB) which are both scarce in the Eco zone, it was concluded that the online banking system and the rest of the variables all contribute to financial inclusiveness. Their findings highlight the critical role of digital financial products on financial inclusion, particularly in terms of enhancing, accessing, and utilizing resources by underserved people.

Myovellaa, Karacukaa, and Haucap (2020) compared the extent of digitalization contribution to economic growth in SSA with developed economies, OECD (Organization for Economic Cooperation and Development). The main rationale behind the comparison between developed and most and least developed economies is to look at the real effects of digitalization and understand whether these effects are country specific. The authors utilized a panel dataset of 41 Sub-Saharan African countries with 11 years (2006 to 2016) time span. Economies from OECD were estimated using the generalized linear methods of moments (GMM) estimators. Results showed that economic growth in Sub-Saharan Africa is perceived to have been spurred by new technologies.

Uzoma *et al.* (2020) attempted to study the relationship between digital finance and financial inclusion in Sub-Saharan African using panel data analysis. They employed the Granger error correction and Generalized Method of Moments to analyse the short panel data, as it was more suitable for dealing with the heteroscedasticity of the dataset. They found that digital finance and financial inclusion had a positive long-run relationship, and concluded that: 'Our model showed that digital finance significantly enhances financial inclusion among the Sub-Saharan African countries'. They further suggested that: 'The relevant monetary authorities of the contemporary emerging and developing economies in the Sub-Saharan African countries promote and maximize the use of DFTs. This can be achieved by directing more commercial banks to install more ATMs and reduce temptation to make cash payments and withdrawals within the frame of work an established regulatory prescription. This study is the first of its kind to address financial inclusion in Sub-Saharan Africa, by providing a comprehensive measurement and investigating the impact of digitalization.

Moreover, studies have been seeing digital financial services as a potential alternative, but little attention has been paid to digital finance as a preferred transmission mechanism especially now that the economies of most countries have to adapt to several changes due to the pandemic, and social distancing. It enforces a cashless policy of no cash for any economic and financial transaction plus a bank verifications number for everyone so only bank account holders are allowed to carry out banking transaction and another scheme known as e-dividend – where you can't get your dividends paid in cash; you need a current account where you get dividends from the proceeds of the shares; then a pension policy – where you get your monthly pension through what they call micro-pension – where your pension goes into a current account with a bank; and they had insurance policy. The last policy is such that if you are to collect any insurance schemes, the insurance house will pay you through a current account. These policies highlight the importance of digital finance in addressing the needs of the excluded and unbanked, especially in rural areas.

McKenzie and Slind (2019) explored increased user-generated content nowadays and the emergence of social media in less developed parts of the world, representing a take-it-or-leave-it opportunity to better understanding the spatial availability and regional unavailability of financial goods in Sub-Saharan Africa. They compared traditional regression models to machine learning solutions in terms of integrating user-generated geo content and geo-social media data into existing spatial data analysis methods, and in terms of alternative data solutions that can be used to develop prediction models for sites providing access to financial services in countries that lack suitable estimation models. Unique geospatial distribution methods that reduce the cost and time of data collection while simultaneously ensuring the most critical information arrives to decision makers faster and more efficiently were discovered. Finally, based on the outcomes of this study, we explain a mobile application that is currently being used to improve data gathering operations on the ground.

Naumenkova, Mishchenko, and Dorofeiev (2019) studied what impact the digitalization, which is underway in Ukraine, has on financial inclusion, using the World Bank and G20 Financial Inclusion indicators methodology to compare the real availability of the traditional ease of use and extent of penetration of financial services for ordinary Ukrainians to the population of the World as a whole. The goal is to untangle barriers to competition, which limit the financial inclusion of Ukrainians. The researchers emphasized the critical nature of adhering to fundamental principles of digital financial inclusion in order to put the activities of financial institutions and their agents in the digital supply of financial services under check, strengthen regulatory

oversight of the usage of new financial products and service systems, and protect the rights of financial services clients in Ukraine.

Abor, Amidu, and Issahaku (2018) explored whether mobile communications increase pro poor development by helping households to live well and get out of poverty by allocating their consumption in an optimal way. To evaluate whether access to diversified and varied kinds of financial services increase the capacity of a household to live well, the authors used the seemingly unrelated probit and instrumental variable technique. The results showed that owning a cell phone and access to financial services reduces a family's likelihood of becoming poor and increases per capita the consumption of food and non-food items. While their results appear promising in helping the poor to increase their welfare, it was revealed that the welfare gains associated with mobile telephones and financial inclusion are not higher by female-headed households. In view of these findings, they concluded that this lays a strong foundation for the state and other people to intensify efforts to improve livelihoods. As a result, these findings provide an excellent starting point for the government and other parties seeking to improve livelihoods and the study creates a fine opening for gender inclusion which can help optimise financial inclusion and which is one of the areas that is also very paramount in the study of financial inclusion.

Ozili (2018) studied the effect of digital finance on the financial inclusion and various challenges as well as implications of digital finance on the financial stability. It identified problems with digital finance and categorized those challenges based on the generalized method of moments, The outcome reveals to us that digital finance can lead to an increase in financial inclusion and whether those increases in financial inclusion will have a positive effect on financial stability at the country level. Additionally, their further aim is to identify those groups of individuals who use digital finance and to understand the factors affecting their decisions to use those payment services. From the outcome, it can be clearly understood that digital finance has positive effect on the financial inclusion and digital finance can be helpful for the user of financial service providers, government and the economy as a whole and they will benefit from the use of digital finance and financial inclusion. However, existing challenges that, if addressed, will improve the effectiveness of digital finance for individuals, businesses and governments. The problems raised in this article are pertinent to the ongoing debate and country-level efforts aimed at increasing financial inclusion in developing and emerging countries through digital finance. The flaw with this manuscript is that it lacks a quantitative study that would be useful to both government and policymakers, thus we can't trust its conclusion.

In their study, Francis, Stuart, and Wellalage (2017) examined the similarity between expanding accessibility to digital financial services (DFS) and financial inclusion in lower-income countries (LICs) in Ghana, they documented that 'there was a positive relationship between improved access to Digital Financial Services (DFS) and financial inclusion in lower-income countries.' Based on ordinary least squares and logistic regression models in Ghana between 2011 and 2014, their findings clearly pointed to the non-bank-based fintech as the most affordable channel to reach the previously unbanked population. As a result, they suggested that the positive major trend of mobile money usage, as well as the negative trend of bank-based DFS services, be given importance and re-emphasized for clear policy implications. As a result, they came to the conclusion that paying much attention to digital innovation promotes favourable results in a more open and welcoming financial system.

Gabor and Brooks (2016) explored the significance of digital-based financial inclusion, their technique of estimation was Generalized Methods of moments. They demonstrate how to appreciate why development policy is being extended into sectors in the South under the rubric of 'development', and their analysis reveals that, over and above the 'unbankeds' access to finance. And concluded by treating financial inclusion and the power of global finance, which has neither been vanquished by nor affected by the 2008 Great Recession, as being intrinsically related. One of the study's major flaws is how challenging it is to comprehend what the author is trying to say in simple terms, which will be difficult for a layperson to comprehend, making it a paper that policymakers may find difficult to implement.

3   Methodology
3.1   Data and Sources

This study was conducted across 46 sub–Saharan African countries using a panel data specification covering 2005 to 2021. This section presents the description and measurement of variables used, (both dependent and independent variables). A robust measure of financial inclusion is very essential in this research work to obtain a reliable estimation over a long time frame across a broad range of the African countries. This is to track a countries' progress towards the achievement of its national inclusion targets as well as the evaluation of its performance and the variables used to measure the index of financial inclusion are depicted in Table 1. Four control variables are included in the model to capture the effect of the countries, taken from the existing literature which is described in Table 2.

3.1   Measurement of Financial Inclusion Index Database

Table 1: Sources of Financial Inclusion Indicators

Dimension	Indicators	Source
ACESS	Number of bank branches per 100,000 adults	IMF (2022)
	Number of ATM per 100,000 adults	IMF (2022)
	Number of Branches per 1000 km^2	IMF (2022)
	Number of ATM per 1000 km^2	IMF (2022)
USAGE	Number of Deposit Account with Commercial Banks per 1000 adults	IMF (2022)
	Number of Loan Account with Commercial Banks per 1000 adults	IMF (2022)
	Outstanding Deposits from Commercial Banks % of GDP	IMF (2022)
	Outstanding Loan from Commercial Banks % of GDP	IMF (2022)
QUALITY	Getting Credit: Depth of Credit Information Index (0-8) (2015-2020) methodology	World Bank (2022)

Source: Authors Compilation (2024).

Table 2: Variables, Descriptions and Sources

Variables	Descriptions	Sources
Percentage of persons using ATM (PPUA)	a measure of digitalization, which is the number of ATMs used per 100,000 adults	IMF (2022)
Inflation rate (INFN)	Annual percentage change in average Consumer price index	World Bank (2022)
GDP per capita (GDPC),	Per capita Real GDP	World Bank (2022)
Internet Use (INU)	Proportion of the population using the internet	World Bank (2022)
Human Development Index (HDI)		United Nations (2022)

Source: Authors Compilation (2024).

3.2   Model Specification

The model specification on the relationship between Digitalization and Financial Inclusion is adapted from Uzoma *et al.* (2020) and is as stated in the functional and the modified model as presented in equation (1) and (2) respectively, which is further explained.

$$FII = f(PPUA, GDPPC, CPI, INU, HDI) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

$$lnFII_{it} = \alpha_0 + \beta_1 PPUA_{it} + \beta_2 Lngdppc1_{it} + \beta_3 lncpi_{it} + \beta_4 Internetuse_{it} + \beta_5 humandev_{it} + \alpha_{t1} + V_{it1} \dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

βs represent the coefficients of the empirical model.

3.3 Estimation Technique

This study follows existing literature in the use of both static and dynamic panel data estimation approaches. To improve our empirical robustness, our reported results are based on both static and dynamic estimation approaches, while the dynamic results are estimated with a two-step system GMM approach, following the dynamic study, we estimate our model using a two-step system GMM approach. Note that using multiple indicators to calculate the financial inclusion index for the economy is crucial and is also a method used to test the robustness of the study. Additionally, this study takes into consideration the unit root test diagnostic. However, it's worth noting that there were some missing values in the datasets for this research, caused by the poor data collection in SSA, leading to the estimation not being possible for the unit root test.

3.3.1 Static Estimation

The study used the estimates made by Fixed Effects (FE) and Random Effects (RE) estimator initially, then Hausman test is used for choosing Random effect and fixed effect model: The null hypothesis is that the regressors are uncorrelated with the unobserved firm specific random errors, If the test statistic rejects this null hypothesis under asymptotic distribution, the random effect estimators will be biased and the correct model is the fixed effect model.

3.3.2 Dynamic Strategies

In the dynamic panel model that we adopt in our study, due to the biases caused by endogeneity of the FE and RE models, and other econometric difficulties, we used the Arellano-Bover/Blundell-Bond system GMM estimator. For example, if the autoregressive process is sufficiently persistent then the model in differences requires no lagged levels as instruments for the residuals in levels. As Arellano and Bover (1995) point out, in small samples, one needs more than two moment conditions because weak instruments can lead to both biased estimates and high frequency instability. Therefore, one set of additional moment conditions requires that the lagged differences of the dependent variable are orthogonal to levels of the disturbances. The estimation requires finding the moment conditions that Arellano-Bond assume are

satisfied: the first differences of the instruments are uncorrelated with the fixed effects.

The following cases are applicable to the Arellano–Bover/Blundell–Bond estimator: Linear dynamic panel dataset. Test equation that has aggregate-level information on the left-hand-side variable, which is dependent on its lag value, and on the right-hand side we have non-strictly exogenous fixed individual effects, heteroskedasticity and autocorrelation within (but not across) individuals. To complement the estimator, we should run some diagnosis tests regarding the GMM estimator. Blundell-Bond suggests three autocorrelation measures, usually once that the panel data has been estimated: the first-order (AR(1)) and second-order (AR(2)) autocorrelation tests. Our GMM estimator is appropriate only if we cannot reject the null for the AR(1) test, and reject only suggestively the null for the AR(2) test. Finally, a diagnostic test usually considered for the estimator is Sargan's test and Hansen's J test of over-identifying restrictions.

Following Roodman (2009) on the difference between the Hansen's J and Sargan's test, we must decide which restricted model to use if the error is heteroscedastic or not heteroscedastic. Either way (for the Sargan's and the Hansen's J tests), we do not expect to reject the null. When the error is homoscedastic, the Sargan statistics can be seen as a special case of Hansen's J. The Sargan test statistic is not a good candidate for a robust GMM. The strategy to address the weak instruments problem should assume a level equation because this way we get a system of two equations. Considering the autoregressive panel data model in equation (3), with the lagged dependent variable ($lnFII_{it-1}$) included as a regressor, making it a dynamic model. The system GMM uses a two-equation approach with additional instruments. Equation (4) is expressed in levels with lagged differences as instruments and Equation (5) is expressed in first differences with lagged levels as instruments.

$lnFII_{it} = \alpha_0 + \beta_1 lnFII_{it-1} + \beta_2 PPUA_{it} + \beta_3 Lngdppc1_{it} + \beta_4 lncpi_{it} + \beta_5 Internetuse_{it} + \beta_6 humandev_{it} + \alpha_{t1} + V_{it1}$……………………………..………(3)

$lnFII_{it} = \alpha_0 + \beta_1 lnFII_{it-1} + \beta_2 PPUA_{it} + \beta_3 Lngdppc1_{it} + \beta_4 lncpi_{it} + \beta_5 Internetuse_{it} + \beta_6 humandev_{it}$ @ $\Delta lnFII_{it-2}$ $\Delta PPUA_{it-1}$ $\Delta Lngdppc1_{it-1}$ $\Delta lncpi_{it-1}$ $\Delta Internetuse_{it-1}$ $\Delta humandev_{it-1}$ … … … … … … … … … … ….. (4)

$\Delta lnFII_{it} = \alpha_0 + \beta_1 \Delta lnFII_{it-1} + \beta_2 \Delta PPUA_{it} + \beta_3 \Delta Lngdppc1_{it} + \beta_4 \Delta lncpi_{it} + \beta_5 \Delta Internetuse_{it} + \beta_6 \Delta humandev_{it}$ @ $lnFII_{it-2}$ $PPUA_{it-1}$ $Lngdppc1_{it-1}$ $lncpi_{it-1}$ $Internetuse_{it-1}$ $humandev_{it-1}$ ………………………………(5)

Note: The @ function is what separates the main equation from the list of instruments. Also worthy of note is that the second lag of the dependent

variable ($lnFII_{it-2}$) is used as instrument for the first lag included as a regressor ($lnFII_{it-1}$) and the lags of the independent variables serves as instruments for their respective underlying regressors in equation (4) and (5).

4.   Results and Discussion

Table 3: Financial Inclusion Index (FII) in Sub-Saharan African Countries

```
    Variable |   Obs     Mean  Std. Dev.    Min      Max
-------------+-------------------------------------------------------
    findex1 |   782   2.00e-08  2.115452  -2.811   10.295
```
Source: Authors computation from Stata

The Table 3 computes financial inclusion index is the analysis of Sub-Saharan countries' financial inclusion index from 2005 to 2021, and the minimum financial inclusion index was recorded in 2005 of -2.811, which was Nigeria. While the maximum financial inclusion index was recorded in 2019 of 10.295 and the country with that was Seychelles, which is the only high income country in the whole region of sub-Saharan Africa.

Table 4: Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
findex1	782	0	2.115	-2.811	10.295
PPUA	782	10.995	16.327	-1.14	92.530
lngdppc2	765	8.077	.89	6.566	10.627
lncpi2	782	4.806	.579	3.668	10.13
internetuse2	662	1.704	1.31	-4.499	7.123
humandev2	782	-.672	.201	-1.211	-.202

Source: Authors' Computation from Stata

The Table 4 gives a detailed report of the summary statistics for the variables for the sample of 46 countries from 2005 to 2021. The data shows a level of variation in the financial inclusion across the countries, which discloses the standard deviation and mean value of the variables employed for the analysis of Digitalization on financial inclusion for SSA economy.

Table 5: Effects of Digitalization on Financial Inclusion in SSA (2005-2021)

Variables	(1) System Gmm	(2) Fixed Effects	(3) Random Effects	(4) Hausman Test
L.findex1	1.513***			
	(0.256)			
L2.findex1	-0.438			
	(0.264)			
PPUA	-0.010**	0.065***	0.066***	0.008
	(0.005)	(0.002)	(0.002)	(0.006)
lngdppc2	0.328**	0.713***	0.779***	1.045**
	(0.159)	(0.188)	(0.157)	(0.441)
lncpi2	0.052	0.254***	0.218***	0.777**
	(0.060)	(0.061)	(0.058)	(0.312)
internetuse2	0.011	0.019	0.018	0.046
	(0.020)	(0.014)	(0.014)	(0.071)
humandev2	-1.047	-0.293	-0.193	2.501
	(0.654)	(0.423)	(0.410)	(1.864)
Constant	-3.430*	-7.889***	-8.168***	-12.188**
	(1.859)	(1.731)	(1.527)	(5.415)
AR(1)	Pvalue=0.014			CHSQ=11.29
AR(2)	Pvalue=0.106			Pvalue=0.046
Sargan test	Pvalue=0.255			
Hansen test	Pvalue=0.425			
Observations	529	648	648	648
R-squared				
F-statistic 996.38		0.687		
Number of cid	40	40	40	40

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source: Authors' Computation.

Table 5 explains the role of digitalization on financial inclusion in SSA region. The first panel is represented by the Computed FI as the dependent variable, the coefficients of lagged values of financial inclusion explain significantly the future occurrences of financial inclusion. For the first panel, we can estimate that the coefficient of the lag are statistically significant which implies the role of time in explaining the increase of financial inclusion in SSA. Using the first difference, the estimation results show a strong negative relationship between digitalization, main explanatory variable, and financial inclusion, which implies that digitalization has a negative effect on financial inclusion in the short run. As to the coefficients of the control variables, the logarithm of per capita GDP (i.e. lngdppc) was positive and significant in all the models, indicating the positive impact of a country's income level on financial inclusion in general. The other variables were insignificant. Table 3

shows that the P-value of the Hausman test indicates that the fixed effect is more preferred than the random effect, but the system GMM is considered superior and more robust than both.

4.1 Autocorrelation Test

The post-estimation tests were all satisfied. The AR(1) p-value of 0.014 indicates low order serial correlation, leading us to reject the null hypothesis of no autocorrelation (i.e., p-value < 0.05). However, since we are primarily interested in testing for higher order serial correlation, we anticipate no high order serial correlation. The insignificant p-value of 0.106 for AR(2) leads us to accept the null hypothesis of no autocorrelation (i.e., p-value > 0.05).

4.3 Validity Test

We accept the null hypothesis on the validity of instruments for both Hansen and Sargan test with p-value of 0.255 and 0.425 respectively satisfies the condition that the p-value are both > 0.05. The long run estimations are made for the significant variables in Tables 4 and 5 which is to ascertain the long-run impact of the variables on the dependent variable, and we discover that Digitalization was insignificant the next year (table 6) but significant in the 3rd year (table 7) which means that a 10% percentage change in digitalization is associated with 0.07% change in financial inclusion in the long run. While even though the log of per capita GDP was positive in the short run (GMM output is usually the short-run) with a 5% change in lngdppc leading to about 0.328% change in financial inclusion, but in the long run, lngdppc had a negative but significant influence on financial inclusion.

Table 6: Long run Estimations for Significant Variables in the Short run

Dependent Variable: Findex

Variable	Coefficient	Std Error	Z	P-Value		95% Conf. Interval
						0.048
_nl_1_(PPUA)	0.019	0.015	1.270	0.244	.0104	
nl_1_(lngdppc2)	-0.639	0.495	-1.290	0.197	-1.611	-0.331

Where _nl_1= (_b[PPUA])/(1-_b[L1.findex1]) which is how the long-run variable was derived through software STATA. (For L1.Findex1) formula $(B_k \% [1-\Phi])$
Source: Author's Calculation.

Table 7: Long run Estimations for significant Variables

Dependent Variable: Findex

Variable	Coeficient	Std Error	Z	P-Value		95% Conf. Interval
_nl_1(PPUA)	0.0068	0.0040	-1.70	0.090	-0.0147	-0.0011
nl_1(lgppc2	-0.2283	0.1293	1.77	0.077	-0.0251	0.4817

Where _nl_1= (_b[lgppc2])/(1-_b[L2.findex1) which is how the long-run variable was derived through software STATA. (For L2. findex1) formula (B_k ⁒ [1-Φ)

Source: Authors' Computation

4.3   Discussion of Results

The findings from this study underscore the urgent need for SSA countries to focus their attention on educating people on the importance of digitalization so as to achieve improved financial inclusion which is in line with Myovellaa *et al.* (2020) who found that the consequence of digitalization is dependent on the country's degree of development. In the short term, the negative coefficient for digitalization attests to the finding by Ozili (2018) who argued that the primness of digital financial services should not be equated to access to digital financial services, but occur mainly in the developing world, were prospective customers prefer to conduct their banking transaction directly with the bank instead of the use of high cost digital services. This opposes the result found by Duvendack and Mader (2020) who reported positive link between the two. It also suggests the challenges that will arise when digitalization becomes more widespread.

This is compounded by the underdeveloped nature of most countries in sub-Saharan Africa (SSA), where the majority of the rural population is financially excluded and are not proficient in using digital devices for transactions. For example, in Nigeria, the recent government policy to redesign the currency has led to a cash shortage. Due to insufficient preparation for these changes, the economy is experiencing a severe shortage of physical cash, forcing people to resort to cashless transactions. However, banks are not adequately equipped to handle the increased demand on their servers. Additionally, many rural residents lack the financial literacy to adapt to this shift, resulting in a significant decrease in the prices of local goods and livestock as they are taken advantage of by those with access to cash. To address these issues, there is an urgent need for financial education and literacy to ensure that digitalization can positively impact financial inclusion in the future.

The finding on internet use shows the low level of access to relevant ICT tools and technology diffusion in SSA. This finding is consistent with Naumenkova *et al.* (2019) who also found the variable to be highly insignificant in Ukraine. It is important to note that access to internet facilities

increases access to financial product and inclusion and hence the need to deepen access. On the other hand, human development index has been captured as an important element in socioeconomic development. Higher literacy rate or level of education for instance increases awareness and access to financial services/use, and thus facilitates financial inclusion. Also, improvement in living conditions accelerates savings and creates more surplus units in the financial system of a country. This will increase the portfolio of financial institutions and creation of more financial products for customers (McKenzie & Slind, 2019).

5.   Conclusion and Recommendations

This study investigates the nexus between digitalization and financial inclusion of 46 SSA countries during the period 2005-2021. The computation of the three sub-indexes of financial inclusion index is measured with Access, usage and Quality indicators. The digitalization is measured in terms of the number of ATM per 100,000 adults (people using ATMs, PPUA). Other independent variables are used as determinant of financial inclusion, such as national income level, measure by consumer price index (inflation), Internet use and Human Development Index (HDI). System GMM is used to test the coefficient estimators of the variables, which are as follows: digitalization has a negative significant influence on financial inclusion in the short run. However, with appropriate policy, in the long run, digitalization has a significant and positive influence on financial inclusion This means that in the long run with great policy implementations and proper orientation and awareness, digitalization will enhance financial inclusion in SSA Countries by enabling the democratization of financial services, improving social welfare and economic growth and reaching the poorest in remote areas and increasing digital literacy. The study's findings can be used by policy makers and financial services providers in SSA to enlarge and improve the scope and boundary of financial inclusion in their various countries.

Our findings have led us to make several recommendations. More research is needed to help develop our understanding of the insights. Further research could focus on the risks that digitalization may pose to users and the sector. Hence it would be of utmost importance to view financial literacy and how it can be utilised as a medium to ensure that the relationship between financial inclusion and digitalization is improved. Thus, Government should concentrate on improving financial literacy and financial inclusion unit's growth in Central Banks by implementing effective programs and also investing in supervision and leverage technology that is targeted at rural dwellers and the least educated in the society. Banks should focus on improving the management of their digitalised Customer awareness of

financial packages through, implementing promotional campaigns targeted at service providers and rural dwellers which will lead to increase in digital financial service users and standardize the digital technical support infrastructure of financial services centres at the municipal level of the Central Bank and various financial institutes. We believe financial innovation incubated in digital centres will stimulate and facilitate digital finance and enhance the national rate of digital payment and digital transactions.

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